^{180}Hf(^{136}Xe,^{136}Xe′γ) 2007Ng03,2008Ta28

History			
Type	Author	Citation	Literature Cutoff Date
Full Evaluation	E. A. Mccutchan	NDS 126, 151 (2015)	1-Feb-2015

2007Ng03: ^{180}Hf(^{136}Xe,^{136}Xe′γ), E(^{136}Xe)=750 MeV. Measured Eγ, Iγ, γγ, γγ(θ)(DCO), γ(particle) coincidences using the Gammasphere array consisting of 100 Compton-suppressed HPGe detectors for γ-rays and CHICO position-sensitive parallel-plate avalanche counter for beam and target like fragments. Coincidence requirement was at least two γ-rays in γ-ray detectors and two correlated particles in CHICO detector.

2008Ta28: ^{232}Th(^{180}Hf,^{180}Hf′γ), E(^{180}Hf)=1300 MeV. Measured Eγ, Iγ, γγ γ(particle) coincidences using the Gammasphere array consisting of 100 Compton-suppressed HPGe detectors for γ-rays and the CHICO position sensitive parallel plate avalanche counter for beam and target-like fragments. Report results similar to 2007Ng03, with extension of bands to higher spins and identification of new interband transitions.

^{180}Hf Levels

E(level)†	Jπ‡	$T_{1/2}$	E(level)†	Jπ‡	E(level)†	Jπ‡
0.0#	0^+		1936.3h 13	8^-	3121.6i 15	13^-
92.8# 5	2^+		1945.3g 10	11^-	3128.3@ 9	12^+
307.9# 7	4^+		2046.5a 8	8^+	3192.6d 12	12^+
640.1# 8	6^+		2112.0d 11	8^+	3299.4b 9	(12^+)
1083.3# 8	8^+		2132.4i 14	9^-	3350.0g 11	15^-
1141.3f 8	8^-		2132.6@ 8	8^+	3383.2c 11	
1183.3a 11	2^+		2262.3f 10	12^-	3430.3h 16	14^-
1199.0@ 9	2^+		2272.5b 9	(8^+)	3605.7& 10	13^+
1290.9& 8	3^+		2273.6# 9	12^+	3677.3@ 9	14^+
1369.9a 10	4^+		2300.1c 10		3732.2i 16	15^-
1372.9h 12	4^-		2348.6h 14	10^-	3755.3f 11	16^-
1384.3g 9	9^-		2353.0e 11	9^+	3780.7a 9	14^+
1408.2@ 8	4^+		2398.2& 9	9^+	3812.7# 10	16^+
1481.1i 13	5^-		2532.2a 9	10^+	3970.4b 9	(14^+)
1556.7& 8	5^+		2586.2i 15	11^-	4089.5h 16	16^-
1611.0h 13	6^-		2602.9g 10	13^-	4180.0g 11	17^-
1630.2# 8	10^+		2612.9@ 8	10^+	4269.4@ 10	16^+
1652.4f 9	10^-		2616.0d 11	10^+	4322.7&j 14	15^+
1658.3a 9	6^+		2729.3b 9	(10^+)	4411.3i 17	17^-
1702.0d 10	6^+	<5k ns	2795.2c 10		4681.2# 11	18^+
1723.2@ 8	6^+		2846.6h 15	12^-	4923.4@j 14	18^+
1763.3i 13	7^-		2898.0e 12	11^+	5553.2#j 15	20^+
1893.9e 11	7^+		2959.9& 9	11^+	5628.4@j 17	20^+
1901.3b 10	(6^+)		2965.2f 10	14^-	5665.2j 15	20^+
1903.3c 10			3004.6# 9	14^+		
1928.0& 8	7^+		3109.9a 9	12^+		

† From a least-squares fit to Eγ's by evaluator. ΔE=1 keV assumed when no uncertainty given.
‡ As proposed by 2007Ng03 based on DCO ratios for selected transitions, decay properties and band assignments.
# Band(A): $K^\pi=0^+$, gs.
@ Band(B): $K^\pi=2^+$, γ-vibrational band, α=0.
& Band(b): $K^\pi=2^+$, γ-vibrational band, α=1.
a Band(C): $K^\pi=0^+$ band.

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^{180}Hf(^{136}Xe,^{136}Xe′γ) 2007Ng03,2008Ta28 (continued)

^{180}Hf Levels (continued)

[b] Band(D): Low-K γ-vibrational band, likely even spin and positive $parity.
[c] Band(E): Low-K γ-vibrational band, likely odd spin.
[d] Band(F): $K^\pi=6^+$ two-quasi particle band, $\pi 7/2[404]\otimes\pi 5/2[402]$, $\alpha=0$.
[e] Band(f): $K^\pi=6^+$ two-quasi particle band, $\pi 7/2[404]\otimes\pi 5/2[402]$, $\alpha=1$.
[f] Band(G): $K^\pi=8^-$ two-quasi particle band, $\pi 7/2[404]\otimes\pi 9/2[514]$, $\alpha=0$.
[g] Band(g): $K^\pi=8^-$ two-quasi particle band, $\pi 7/2[404]\otimes\pi 9/2[514]$, $\alpha=1$.
[h] Band(H): $K^\pi=4^-$ two-quasi particle band, $\nu 9/2[624]\otimes\nu 1/2[510]$, $\alpha=0$.
[i] Band(h): $K^\pi=4^-$ two-quasi particle band, $\nu 9/2[624]\otimes\nu 1/2[510]$, $\alpha=1$.
[j] Observed only by 2008Ta28.
[k] From comparison of γ-ray intensities across the bandhead for varying width of coincidence time window.

γ(^{180}Hf)

DCO ratio=(I_γ(30° or 150°,90°))/(I_γ(90°,30° or 150°)), where $I_\gamma(\theta_1,\theta_2)$ is the intensity of the γ transition observed at angle θ_1 in coincidence with a ΔJ=2, stretched quadrupole γ at θ_2. The DCO ratio is expected to be 1.0 for ΔJ=2, stretched quadrupole and 0.5 for ΔJ=1, dipole.

E_γ[†]	I_γ[#]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[@]	Comments
57.8 *5*		1141.3	8^-	1083.3	8^+		
92.8 *5*	23.1 *8*	92.8	2^+	0.0	0^+		
108.2 *5*	0.67 *4*	1481.1	5^-	1372.9	4^-		
129.7 *5*	0.207 *9*	1611.0	6^-	1481.1	5^-		
152.2 *5*	0.13 *2*	1763.3	7^-	1611.0	6^-		
173.0 *5*	0.07 *1*	1936.3	8^-	1763.3	7^-		
186.6 *5*		1369.9	4^+	1183.3	2^+		
192.0 *5*		1893.9	7^+	1702.0	6^+		
196.2 *5*	0.04 *1*	2132.4	9^-	1936.3	8^-		
209 *1*		1408.2	4^+	1199.0	2^+		
215.3 *5*	107 *4*	307.9	4^+	92.8	2^+		
216.2 *5*		2348.6	10^-	2132.4	9^-		
218.3 *5*	0.23 *1*	2112.0	8^+	1893.9	7^+		
238.1 *5*	0.36 *1*	1611.0	6^-	1372.9	4^-		
241.0 *5*	0.19 *1*	2353.0	9^+	2112.0	8^+		
242.9 *5*	1.44 *4*	1384.3	9^-	1141.3	8^-		
263.0 *5*	0.11 *1*	2616.0	10^+	2353.0	9^+		
266.1 *5*		1556.7	5^+	1290.9	3^+		
268.1 *5*	1.24 *2*	1652.4	10^-	1384.3	9^-		
282.0 *5*	0.04 *1*	2898.0	11^+	2616.0	10^+		
282.3 *5*	0.46 *2*	1763.3	7^-	1481.1	5^-		
288.4 *5*		1658.3	6^+	1369.9	4^+		
293.0 *5*	0.59 *1*	1945.3	11^-	1652.4	10^-		
294.5 *5*		3192.6	12^+	2898.0	11^+		
314.8 *5*	0.53 *5*	1723.2	6^+	1408.2	4^+		
316.9 *5*	0.27 *1*	2262.3	12^-	1945.3	11^-		
325.3 *5*	0.27 *2*	1936.3	8^-	1611.0	6^-		
332.2 *5*	100 *3*	640.1	6^+	307.9	4^+	E2	Mult.: R(DCO)=1.12 *2*.
340.6 *5*	0.14 *1*	2602.9	13^-	2262.3	12^-		
362.3 *5*	0.06 *1*	2965.2	14^-	2602.9	13^-		
369.1 *5*	0.25 *4*	2132.4	9^-	1763.3	7^-		
371.1 *5*	0.08 *2*	2272.5	(8^+)	1901.3	(6^+)		
371.2 *5*	0.51 *3*	1928.0	7^+	1556.7	5^+		
384.8 *5*	0.03 *1*	3350.0	15^-	2965.2	14^-		

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^{180}Hf(^{136}Xe,^{136}Xe′γ) 2007Ng03,2008Ta28 (continued)

γ(^{180}Hf) (continued)

E_γ[†]	I_γ[#]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[@]	Comments
388.1 *5*	0.32 *3*	2046.5	8^+	1658.3	6^+		
396.8 *5*	0.36 *3*	2300.1		1903.3			
405.4 *5*	0.02 *1*	3755.3	16^-	3350.0	15^-		
409.0 *5*	1.02 *6*	2132.6	8^+	1723.2	6^+		
409.9 *5*	0.04 *1*	2112.0	8^+	1702.0	6^+		
412.2 *5*	0.20 *1*	2348.6	10^-	1936.3	8^-		
424.8 *5*		4180.0	17^-	3755.3	16^-		
443.4 *5*	51.9 *15*	1083.3	8^+	640.1	6^+	E2	Mult.: R(DCO)=1.16 *2*.
453.8 *5*	0.15 *1*	2586.2	11^-	2132.4	9^-		
456[‡]		4269.4	16^+	3812.7	16^+		
456.7 *5*	0.27 *2*	2729.3	(10^+)	2272.5	(8^+)		
459.0 *5*	0.08 *1*	2353.0	9^+	1893.9	7^+		
470.4 *5*	0.21 *2*	2398.2	9^+	1928.0	7^+		
480.3 *5*	0.53 *4*	2612.9	10^+	2132.6	8^+		
485.2 *5*	0.14 *3*	2532.2	10^+	2046.5	8^+		
495.1 *5*	0.09 *2*	2795.2		2300.1			
498.0 *5*	0.09 *1*	2846.6	12^-	2348.6	10^-		
501.4 *5*		1141.3	8^-	640.1	6^+		
504.0 *5*	0.07 *1*	2616.0	10^+	2112.0	8^+		
511.2 *5*	0.13 *2*	1652.4	10^-	1141.3	8^-		
515.4 *5*	0.17 *2*	3128.3	12^+	2612.9	10^+		
535.4 *5*	0.07 *2*	3121.6	13^-	2586.2	11^-		
545.0 *5*	0.05 *1*	2898.0	11^+	2353.0	9^+		
547.3 *5*	24.5 *6*	1630.2	10^+	1083.3	8^+	E2	Mult.: R(DCO)=1.12 *2*.
548.9 *5*	0.13 *2*	3677.3	14^+	3128.3	12^+		
560.9 *5*	0.08 *2*	1945.3	11^-	1384.3	9^-		
561.7 *5*	0.10 *1*	2959.9	11^+	2398.2	9^+		
569.8 *5*	0.18 *2*	3299.4	(12^+)	2729.3	(10^+)		
576.7 *5*		3192.6	12^+	2616.0	10^+		
577.8 *5*	0.04 *2*	3109.9	12^+	2532.2	10^+		
583.7 *5*		3430.3	14^-	2846.6	12^-		
588.0 *5*		3383.2		2795.2			
592.3 *5*	0.05 *2*	4269.4	16^+	3677.3	14^+		
596.7 *5*	0.11 *2*	2729.3	(10^+)	2132.6	8^+		
610.0 *5*	0.10 *1*	2262.3	12^-	1652.4	10^-		
610.6 *5*		3732.2	15^-	3121.6	13^-		
643.4 *5*	10.1 *4*	2273.6	12^+	1630.2	10^+	(E2)	Mult.: R(DCO)=1.06 *2*.
645.8 *5*	0.05 *1*	3605.7	13^+	2959.9	11^+		
654[‡]		4923.4	18^+	4269.4	16^+		
657.5 *5*	0.06 *1*	2602.9	13^-	1945.3	11^-		
659.2 *5*		4089.5	16^-	3430.3	14^-		
670.8 *5*	0.04 *2*	3780.7	14^+	3109.9	12^+		
671.0 *5*		3970.4	(14^+)	3299.4	(12^+)		
673[‡]		3677.3	14^+	3004.6	14^+		
679.1 *5*		4411.3	17^-	3732.2	15^-		
686.8 *5*	0.09 *2*	3299.4	(12^+)	2612.9	10^+		
703.0 *5*	0.05 *1*	2965.2	14^-	2262.3	12^-		
705[‡]		5628.4	20^+	4923.4	18^+		
717[‡]		4322.7	15^+	3605.7	13^+		
730.9 *5*	3.25 *3*	3004.6	14^+	2273.6	12^+	(E2)	Mult.: R(DCO)=1.03 *2*.
747.2 *5*	0.03 *3*	3350.0	15^-	2602.9	13^-		
767 *1*		2398.2	9^+	1630.2	10^+		E_γ: from Fig. 2 of 2007Ng03, not listed in authors′ Table I.
776.1 *5*		3780.7	14^+	3004.6	14^+		
790.0 *5*		3755.3	16^-	2965.2	14^-		

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^{180}Hf(^{136}Xe,^{136}Xe′γ) 2007Ng03,2008Ta28 (continued)

γ(^{180}Hf) (continued)

E_γ [†]	I_γ [#]	E_i(level)	J_i^π	E_f	J_f^π	Mult. [@]	Comments
807.9 *5*	0.78 *2*	3812.7	16^+	3004.6	14^+	(E2)	Mult.: R(DCO)=0.98 *3*.
829.8 *5*		4180.0	17^-	3350.0	15^-		
836.3 *5*	0.07 *1*	3109.9	12^+	2273.6	12^+		
844.9 *5*	0.07 *1*	1928.0	7^+	1083.3	8^+		
868.5 *5*	0.13 *1*	4681.2	18^+	3812.7	16^+		
872[‡]		5553.2	20^+	4681.2	18^+		
902.4 *5*	0.10 *1*	2532.2	10^+	1630.2	10^+		
916.1 *5*	0.22 *2*	1556.7	5^+	640.1	6^+		
962.9 *5*	0.17 *2*	2046.5	8^+	1083.3	8^+		
965.7 *5*		3970.4	(14^+)	3004.6	14^+		
983.0 *5*	0.18 *3*	2612.9	10^+	1630.2	10^+		
983.4 *5*	0.57 *3*	1290.9	3^+	307.9	4^+		
984[‡]		5665.2	20^+	4681.2	18^+		
1018 *1*	0.31 *2*	1658.3	6^+	640.1	6^+	(D+Q)	Mult.: R(DCO)=1.05 *6*. Mult.: stretched Q or unstretched D+Q from R(DCO). (D+Q) from level scheme.
1026 *1*		3299.4	(12^+)	2273.6	12^+		
1050 *1*	0.89 *2*	2132.6	8^+	1083.3	8^+	D	Mult.: R(DCO)=0.69 *3*.
1062 *1*	0.31 *2*	1702.0	6^+	640.1	6^+		
1065 *1*		1372.9	4^-	307.9	4^+		
1083 *1*	1.36 *3*	1723.2	6^+	640.1	6^+	D	Mult.: R(DCO)=0.72 *3*.
1098 *1*	0.58 *4*	2729.3	(10^+)	1630.2	10^+	(D+Q)	Mult.: R(DCO)=0.91 *5*.
1100 *1*	2.3 *2*	1408.2	4^+	307.9	4^+		
1106 *1*	1.13 *3*	1199.0	2^+	92.8	2^+		
1110[a] *1*		3383.2		2273.6	12^+		
1165 *1*		2795.2		1630.2	10^+		
1189 *1*	0.70 *4*	2272.5	(8^+)	1083.3	8^+		
1198 *1*	3.1 *2*	1290.9	3^+	92.8	2^+		
1217 *1*		2300.1		1083.3	8^+		
1249 *1*	1.65 *8*	1556.7	5^+	307.9	4^+		
1261 *1*	0.16 *2*	1901.3	(6^+)	640.1	6^+		
1263 *1*	0.36 *3*	1903.3		640.1	6^+		
1265[‡]		4269.4	16^+	3004.6	14^+		
1288 *1*	1.00 *5*	1928.0	7^+	640.1	6^+	D	Mult.: R(DCO)=0.62 *3*.
1315[&] *1*	1.35[&] *5*	1408.2	4^+	92.8	2^+		
1315[&] *1*	0.44[&] *2*	2398.2	9^+	1083.3	8^+	D	Mult.: R(DCO)=0.62 *4*.
1330 *1*	0.21 *2*	2959.9	11^+	1630.2	10^+		
1332 *1*	0.06 *1*	3605.7	13^+	2273.6	12^+		
1350 *1*	0.07 *1*	1658.3	6^+	307.9	4^+		
1394 *1*	0.40 *5*	1702.0	6^+	307.9	4^+		
1404 *1*		3677.3	14^+	2273.6	12^+		
1415 *1*	1.40 *2*	1723.2	6^+	307.9	4^+	(E2)	Mult.: R(DCO)=1.07 *3*.
1493 *1*	1.35 *2*	2132.6	8^+	640.1	6^+	(E2)	Mult.: R(DCO)=1.07 *3*.
1498 *1*	0.28 *2*	3128.3	12^+	1630.2	10^+	(E2)	Mult.: R(DCO)=1.02 *5*.
1530 *1*	0.47 *4*	2612.9	10^+	1083.3	8^+	(E2)	Mult.: R(DCO)=1.01 *4*.
1669 *1*		3299.4	(12^+)	1630.2	10^+		

[†] From 2007Ng03, except where noted. Uncertainty is stated by 2007Ng03 as ≈0.5 keV. The evaluator assigns 1 keV for Eγ′s above 1000, quoted to nearest keV.
[‡] Observed only by 2008Ta28.
[#] From 2007Ng03, normalized to Iγ(332γ)=100.

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^{180}Hf(^{136}Xe,^{136}Xe′γ) 2007Ng03,2008Ta28 (continued)

$\gamma(^{180}Hf)$ (continued)

@ From R(DCO) measurements in 2007Ng03. Stretched quadrupole transitions are assumed as E2.
& Multiply placed with intensity suitably divided.
a Placement of transition in the level scheme is uncertain.

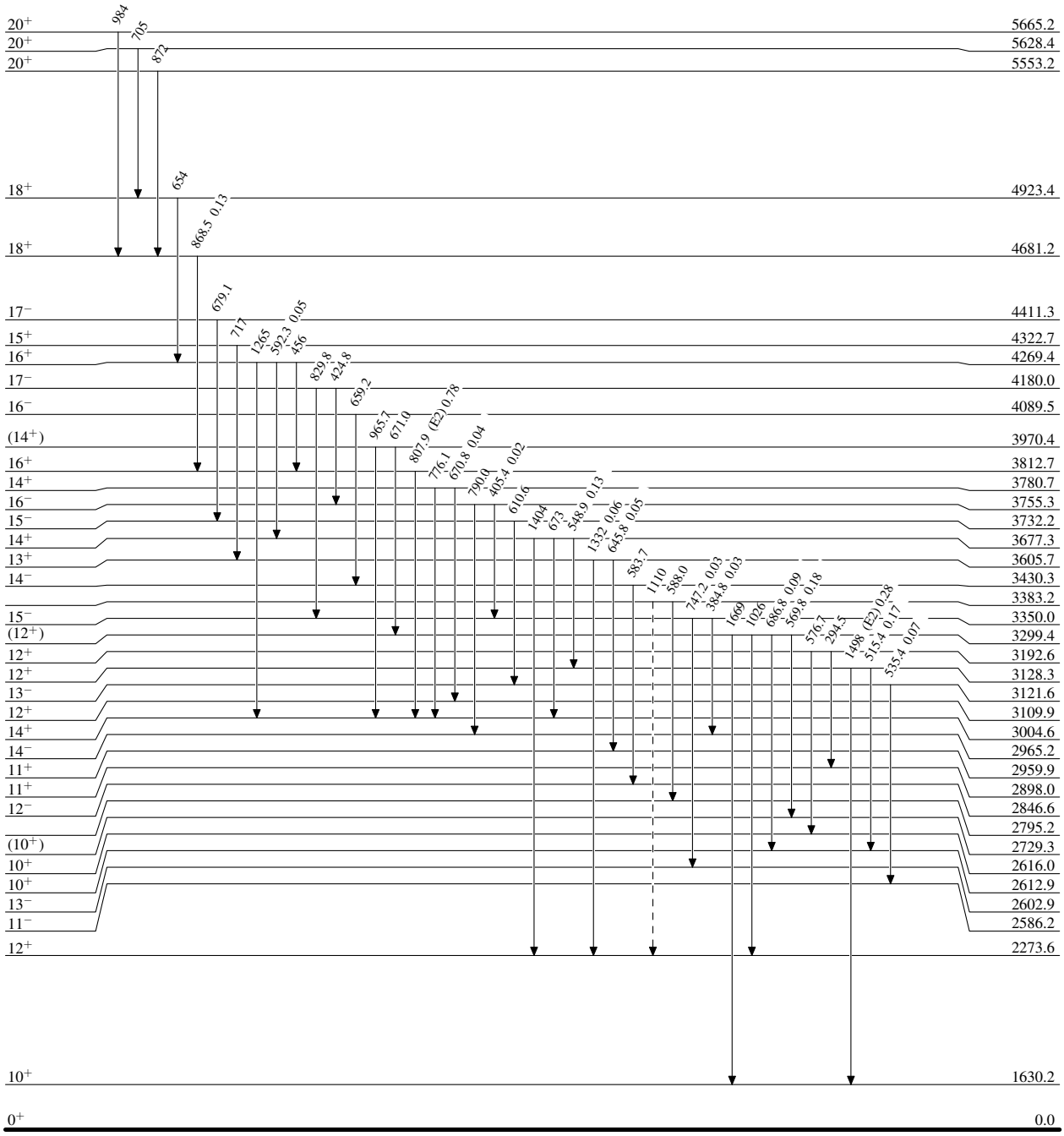
^{180}Hf(^{136}Xe,^{136}Xe′γ) 2007Ng03,2008Ta28

Level Scheme

Intensities: Relative I_γ

Legend

- $I_\gamma < 2\% \times I_\gamma^{max}$
- $I_\gamma < 10\% \times I_\gamma^{max}$
- $I_\gamma > 10\% \times I_\gamma^{max}$
- γ Decay (Uncertain)



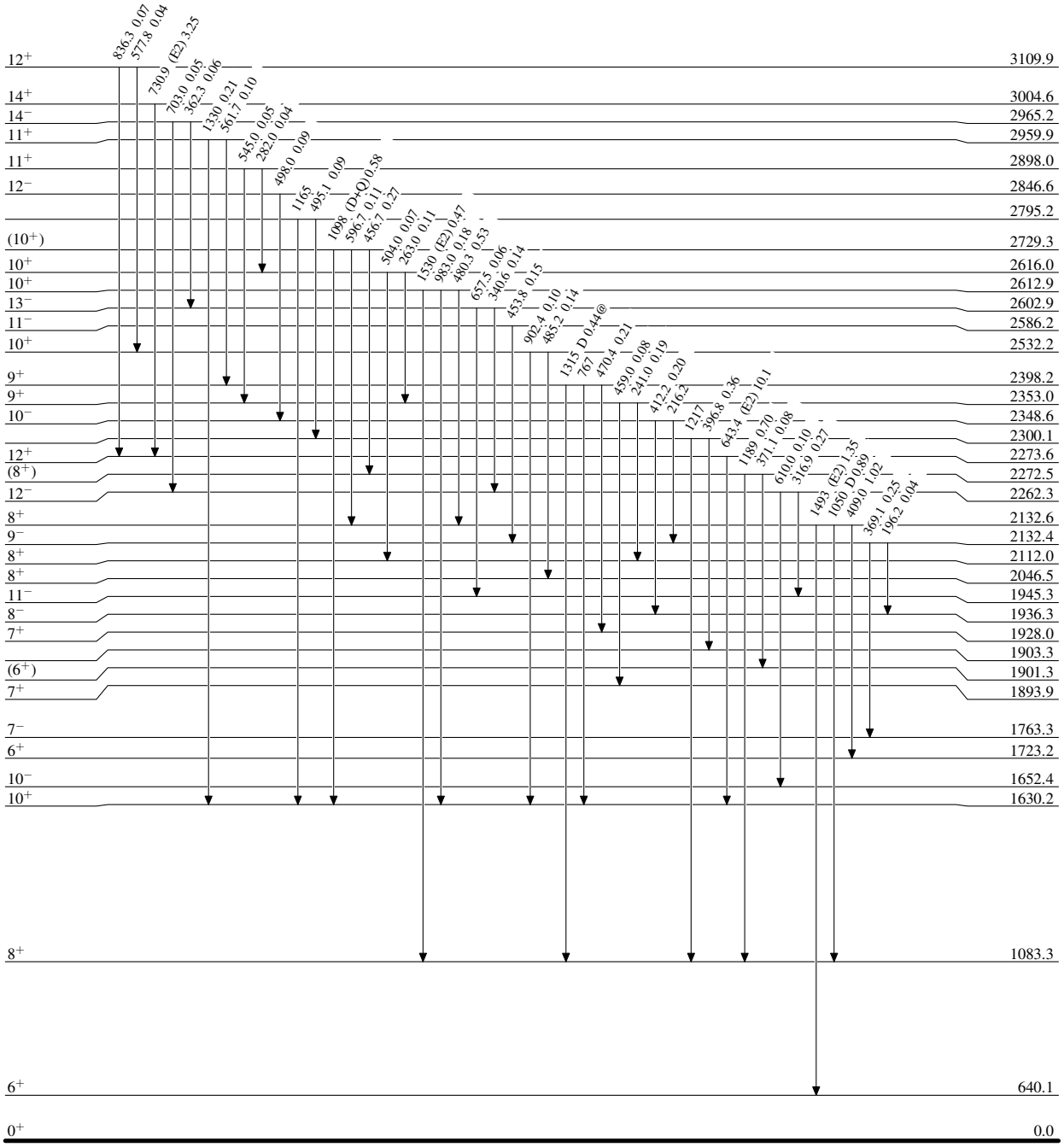
$^{180}_{72}Hf_{108}$

^{180}Hf(^{136}Xe,^{136}Xe′γ) 2007Ng03,2008Ta28

Level Scheme (continued)

Intensities: Relative I_γ
@ Multiply placed: intensity suitably divided

Legend
$I_\gamma < 2\% \times I_\gamma^{max}$
$I_\gamma < 10\% \times I_\gamma^{max}$
$I_\gamma > 10\% \times I_\gamma^{max}$



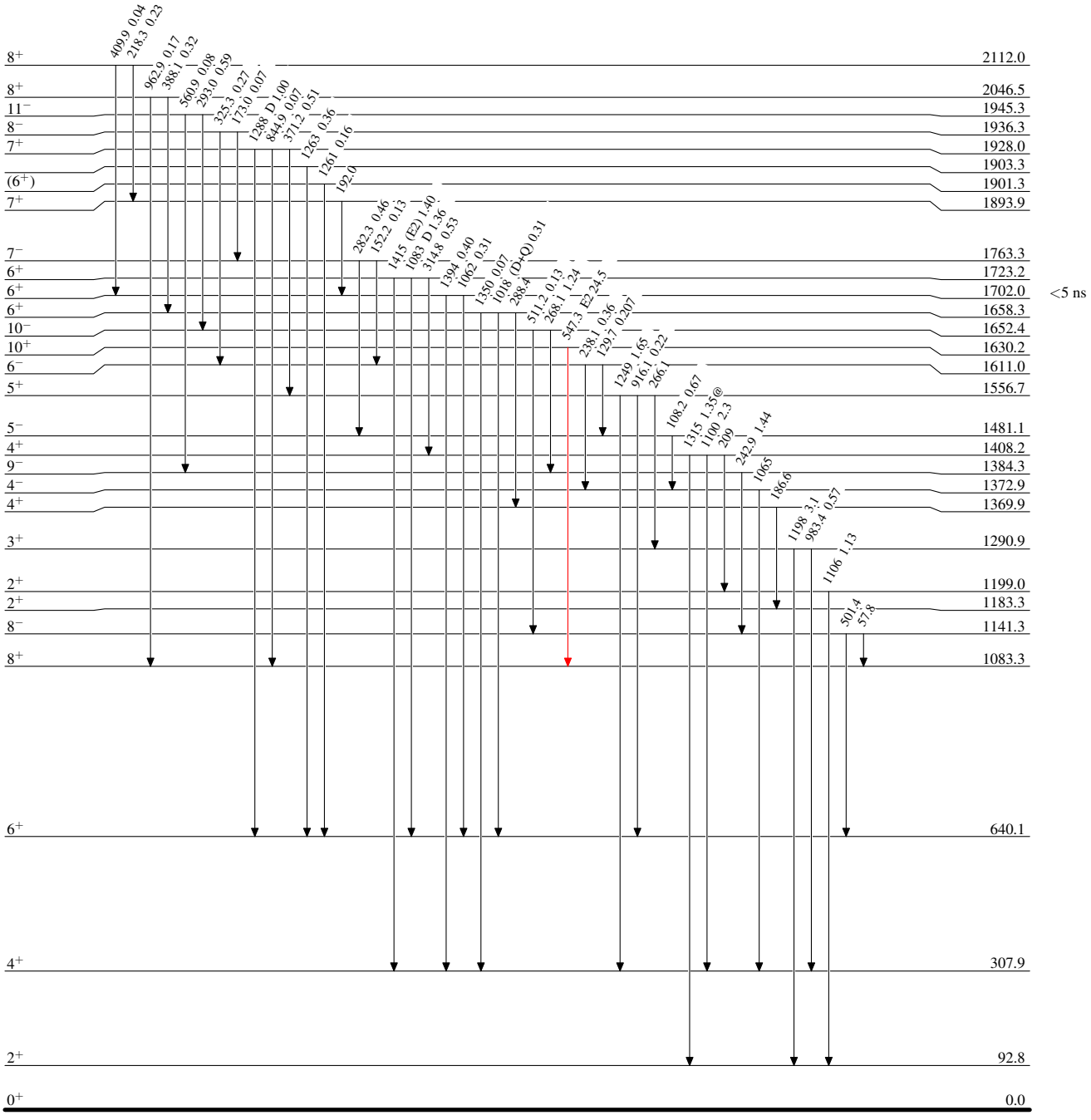
$^{180}_{72}Hf_{108}$

^{180}Hf(^{136}Xe,^{136}Xe′γ) 2007Ng03,2008Ta28

Level Scheme (continued)

Intensities: Relative I_γ
@ Multiply placed: intensity suitably divided

Legend
$I_\gamma < 2\% \times I_\gamma^{max}$
$I_\gamma < 10\% \times I_\gamma^{max}$
$I_\gamma > 10\% \times I_\gamma^{max}$



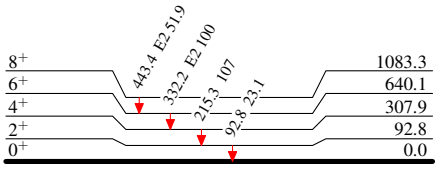
$^{180}_{72}Hf_{108}$

^{180}Hf(^{136}Xe,^{136}Xe$'\gamma$) 2007Ng03,2008Ta28

Level Scheme (continued)

Intensities: Relative I_γ

@ Multiply placed: intensity suitably divided



$^{180}_{72}Hf_{108}$

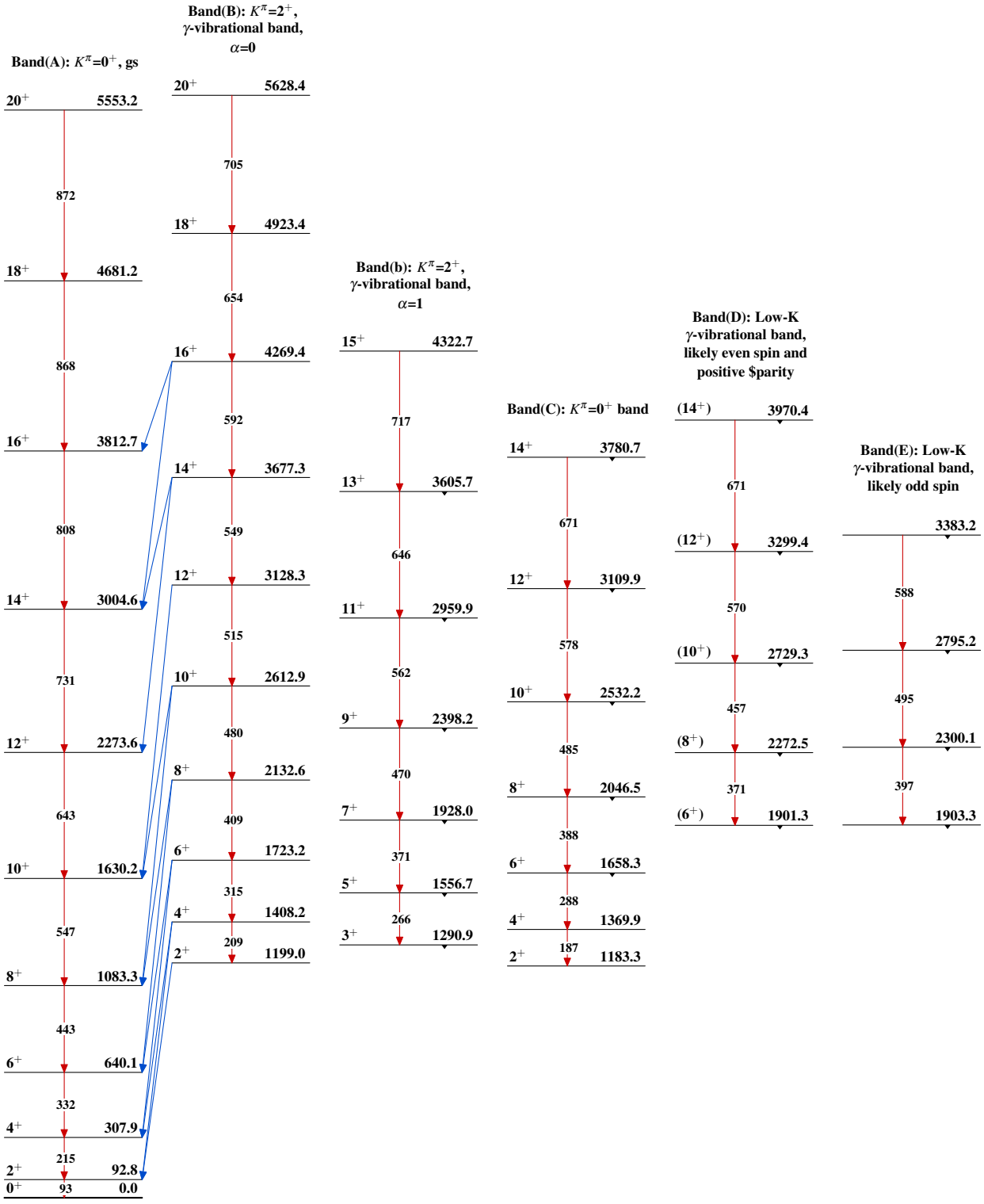
Legend

$I_\gamma < 2\% \times I_\gamma^{max}$

$I_\gamma < 10\% \times I_\gamma^{max}$

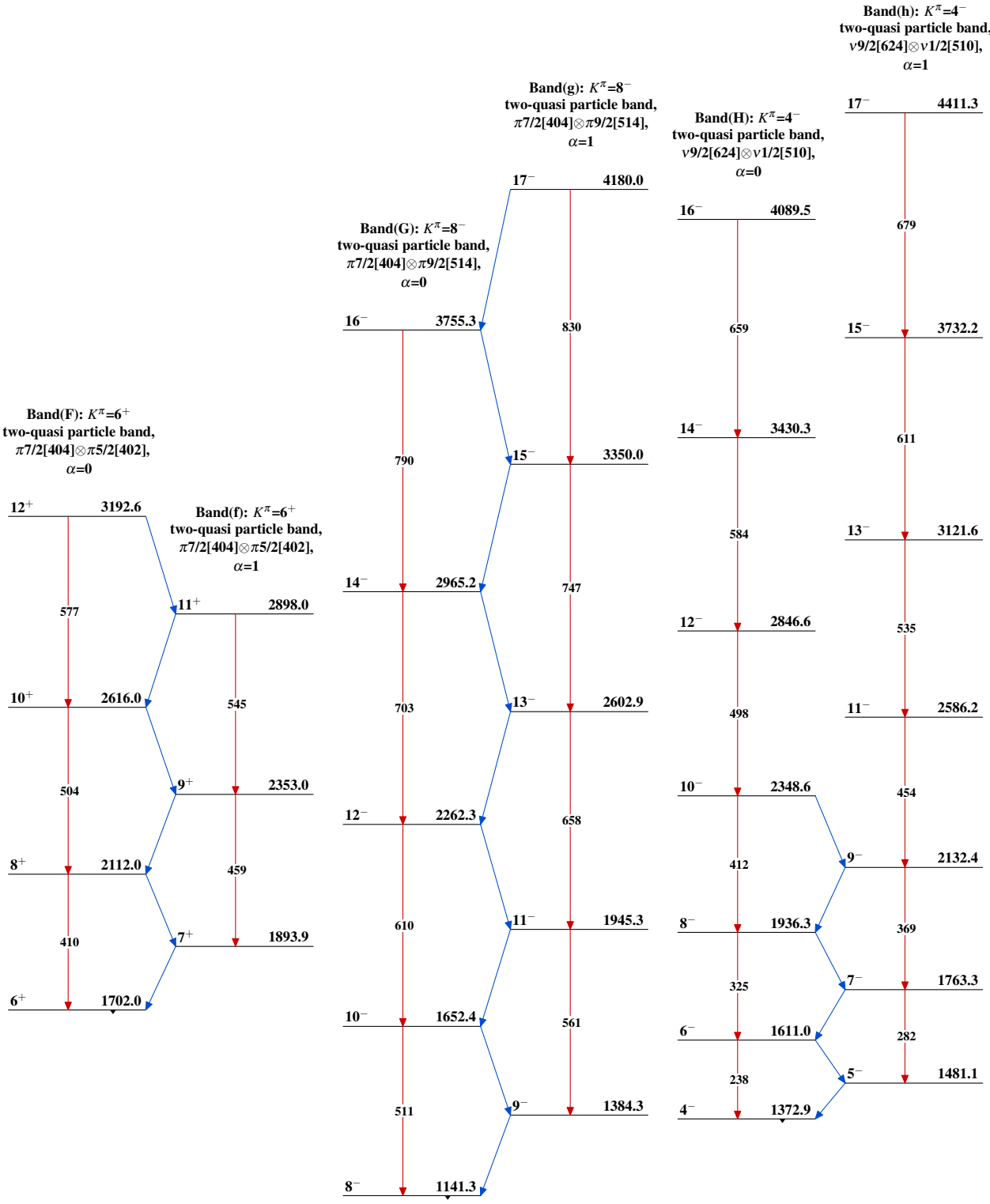
$I_\gamma > 10\% \times I_\gamma^{max}$

^{180}Hf(^{136}Xe,^{136}Xe′γ) 2007Ng03,2008Ta28



$^{180}_{72}Hf_{108}$

^{180}Hf(^{136}Xe,^{136}Xe′γ) 2007Ng03,2008Ta28 (continued)



$^{180}_{72}Hf_{108}$